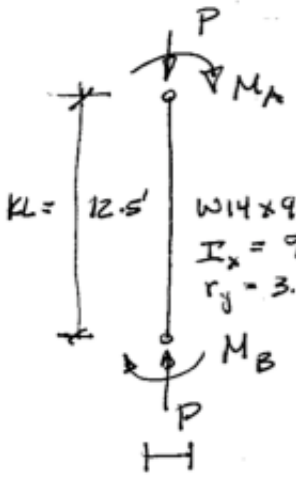
I. Complete the following problems from the textbook (LRFD only):
Chapter 8 – Beam-Columns: 8-1, 8-5, 8-11, 8-13, 8-17, 8-25a, 8-26a

8-1

1. FIRST-ORDER ANALYSIS RESULTS:

$P_D = 100^K$, $P_L = 300^K$, $M_{D_A} = 30$ Ft-K, $M_{L_A} = 70$ Ft-K

$M_{D_B} = 15$ Ft-K, $M_{L_B} = 35$ Ft-K



a) LRFD

$P_u = 1.2(100) + 1.6(300) = 600^K$

$M_{u_A} = 1.2(30) + 1.6(70) = 148$ Ft-K

$M_{u_B} = 1.2(15) + 1.6(35) = 74$ Ft-K

From Appendix 8, DETERMINE AMPLIFICATION FACTOR, B_1

$C_m = 0.6 - 0.4\left(\frac{74}{148}\right) = 0.4$

$P_{e_1} = \frac{\pi^2 EI}{(KL)^2} = \frac{\pi^2(29000)(999)}{(12.5(12))^2} = 12,700^K$

$B_1 = \frac{0.4}{1 - \frac{600}{12,700}} = 0.420 > 1.0 \therefore B_1 = 1.0$

AMPLIFIED MOMENT $M_u = 1.0(148) = 148$ ft-k

Column STRENGTH

For $KL_y = 12.5$ ft $\phi P_n = 1060^K$ TABLE 4-1

For $L_b = 12.5$ ft $\phi M_n = 574$ Ft-K TABLE 3-2

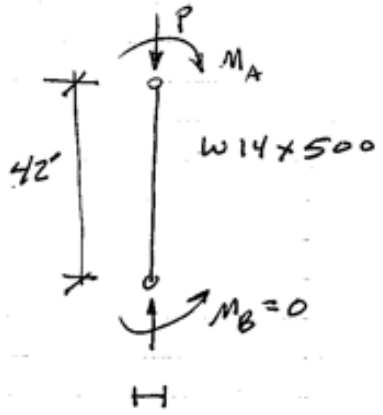
$\frac{P_u}{\phi P_n} = \frac{600}{1060} = 0.566 > 0.2 \therefore$ USE EQ H1-1a

$0.566 + \frac{8}{9}\left(\frac{148}{574}\right) = 0.566 + 0.229 = 0.795 < 1.0$
$\therefore$ OK

8-5

5. First-order analysis results

$P_D = 90\ k$, $P_L = 270\ k$



a) LRFD

$P_u = 1.2(90) + 1.6(270) = 540\ k$

$\phi P_n = 2570\ k$ for $KL_y = 42$ ft from Table 4-1

$\frac{P_u}{\phi P_n} = \frac{540}{2570} = 0.210 > 0.2 \therefore$ use H1-1a

$$0.210 + \frac{8}{9}\left(\frac{M_u}{\phi M_n}\right) \le 1.0 \therefore \frac{8}{9}\left(\frac{M_u}{\phi M_n}\right) = 0.790$$

$b_x = 0.241 \times 10^{-3}$ with $L_b = 42'$ From Table 6-1

$$M_r = \frac{0.790}{0.241 \times 10^{-3}} = 3280\ k \text{ (2nd order moment)}$$

Determine amplification factor B_1

$$C_m = 0.6 - 0.4\left(\frac{0}{M_A}\right) = 0.6$$

$$P_{e_1} = \frac{\pi^2 EI}{(KL)^2} = \frac{\pi^2(29000)(8210')}{(42(12))^2} = 9,250\ k$$

$$B_1 = \frac{0.6}{1 - \frac{540}{9250}} = 0.64 < 1.0 \therefore B_1 = 1.0$$

Thus with a live to dead load ratio of 3

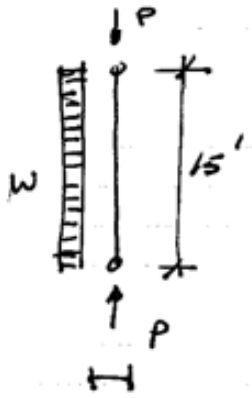
$1.2M_D + 1.6(3M_D) = 3280$ ft-kips

$M_D = 547$ ft-kips $M_L = 3M_D = 1640$ ft-kips

8-11

11. RESULTS OF FIRST-ORDER ANALYSIS

$P_D = 85^K$, $P_L = 280^K$, $w_D = 0.4^K/ft$, $w_L = 1.3^K/ft$



W 14 x 74 with Transverse load, $C_m = 1.0$

$I_x = 795\ in.^4$

a) LRFD

$$P_u = 1.2(85) + 1.6(280) = 550^K$$

$$w_u = 1.2(0.4) + 1.6(1.3) = 2.56^K/ft$$

$$M_u = \frac{2.56(15)^2}{8} = 72^{IK}$$

WITH TRANSVERSE LOAD,

$C_m = 1.0$

$$P_{e_1} = \frac{\pi^2(29000)(795)}{(15(12))^2} = 7020^K$$

$$B_1 = \frac{1.0}{1 - \frac{1.0(550)}{7020}} = 1.09$$

AMPLIFIED MOMENT $M_u = 1.09(72) = 78.5\ ft\text{-}kips$

Column STRENGTH, FOR $KL_y = 15\ ft$ $\phi P_n = 667\ kips$

For $L_b = 15ft$ $\phi M_n = 421\ ft\text{-}kips$

$$\frac{P_u}{\phi P_n} = \frac{550}{667} = 0.825 > 0.2 \quad \therefore \text{USE H1-1a}$$

$$0.825 + \frac{8}{9}\left(\frac{78.5}{421}\right) = 0.825 + 0.166 = 0.991 < 1.0$$

$\therefore$ OK

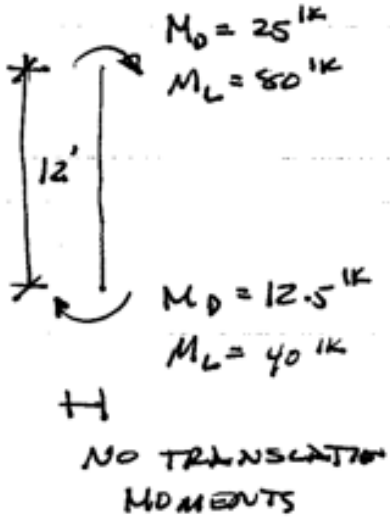
8-13

13. W14 × 109 A992, $I_x = 1240\ in.^4$

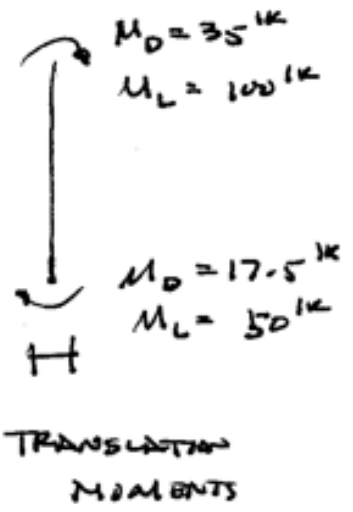
RESULTS OF A FIRST-ORDER ANALYSIS

NO TRANSLATION $P_D = 100^K$, $P_L = 300^K$, $P_{story} = 15\ P_r$

For $H = 150^K$ $\Delta_H = \frac{L}{400} = \frac{12(12)}{400} = 0.36\ in.$



NO TRANSLATION MOMENTS



TRANSLATION MOMENTS

$K_x = 1.06$

$K_y = 1.0$

a) LRFD

$$P_{nt} = P_u = 1.2(100) + 1.6(300) = 600^K$$

$$M_{nt_{TOP}} = 1.2(25) + 1.6(80) = 158^{IK}$$

$$M_{lt_{TOP}} = 1.2(35) + 1.6(100) = 202^{IK}$$

$$M_{nt_{BOT}} = 1.2(12.5) + 1.6(40) = 79^{IK}$$

$$M_{lt_{BOT}} = 1.2(17.5) + 1.6(50) = 101^{IK}$$

13 CONTINUED

AMPLIFICATION

B_1, $C_m = 0.6 - 0.4\left(\frac{1}{2}\right) = 0.2$

$$P_{e_1} = \frac{\pi^2(29000)(1240)}{(12(12))^2} = 17100^K$$

$$B_1 = \frac{0.4}{1 - \frac{1.0(600)}{1710}} = 0.415 < 1.0 \therefore B_1 = 1.0$$

B_2, GIVEN $H = 150^K$ $\Delta_H = 0.36$ in.

$$P_{e_{STORY}} = R_M \frac{HL}{\Delta_H}$$

IF ALL COLUMNS IN MOMENT FRAME, AND CONSERVATIVE IN ALL CASES, $R_M = 0.85$

$$P_{e_{STORY}} = 0.85(150)\frac{(12)(12)}{0.36} = 51,000$$

$$P_{STORY} = 15\,P_r = 15(600) = 9000^K$$

$$B_2 = \frac{1}{1 - \frac{1.0(900)}{51,000}} = 1.21$$

Amplified Moments and Forces

$$M_r = 1.0(158) + 1.21(202) = 402^{IK}$$

$$P_r = 600 + 1.21(0) = 600^K$$

13 (CONTINUED) $KL_x/r_x/r_y = \frac{1.66(12)}{1.67} = 11.9' < KL_y = 12.0\text{ft}.$

COLUMN STRENGTH FOR $KL_y = 12\text{ft}$ $\phi P_n = 1290^K$

FOR $L_b = 12\text{ft}$ $\phi M_n = 720\ \text{ft-kips}$

$$\frac{P_u}{\phi P_n} = \frac{600}{1290} = 0.465 > 0.2 \quad \therefore \text{USE H1-1a}$$

$$0.465 + \frac{8}{9}\left(\frac{402}{720}\right) = 0.465 + 0.498 = 0.961 \leq 1.0$$

$\therefore$ OK

8-17

17. FOR THE LOADING SHOWN, CONSIDER THE APPROPRIATE LIVE, DEAD, AND WIND COMBINATIONS

AS GIVEN: THE GRAVITY LOADS ARE THE NO-TRANSLATION EFFECTS AND THE WIND LOAD IS THE TRANSLATION EFFECT.

a) LRFD – CONSIDER $1.2D + 0.5L + 1.0W$

UPPER STORY

$P_{nt} = 1.2(21.6) + 0.5(24) = 37.9$ K

$P_{lt} = 1.0(0.9) = 0.9$ K

$M_{nt_{TOP}} = 1.2(61.7) + 0.5(68.5) = 108$ FT-K

$M_{lt_{TOP}} = 1.0(11.4) = 11.4$ FT-K

$M_{nt_{BOT}} = 1.2(49.3) + 0.5(54.8) = 86.6$ FT-K

$M_{lt_{BOT}} = 1.0(6.0) = 6.0$ FT-K

LOWER STORY

$P_{nt} = 1.2(43.2) + 0.5(48) = 75.8$ K

$P_{lt} = 1.0(3.24) = 3.24$ K

$M_{nt_{TOP}} = 1.2(24.7) + 0.5(27.5) = 43.4$ FT-K

$M_{lt_{TOP}} = 1.0(21.5) = 21.5$ FT-K

$M_{nt_{BOT}} = 1.2(12.4) + 0.5(13.8) = 21.8$ FT-K

$M_{lt_{BOT}} = 1.0(30.7) = 30.7$ FT-K

17 (continued)

DETERMINE EFFECTIVE LENGTH FACTORS FROM ALIGNMENT CHART. ASSUME CHART ASSUMPTIONS ARE SATISFIED

W14x53, $I_x = 541$ in.^{4} W18x65, $I_x = 1070$ in.^{4}

Top Column

$$G_T = \frac{\frac{541}{12}}{\frac{1070}{24}} = 1.01$$

$$G_B = \frac{\frac{2(541)}{12}}{\frac{1070}{24}} = 2.02$$

$K_x = 1.45$

Bottom Column

$G_T = 2.02$

$G_B = 1.0$ Commentary pg 16.1-513

$K_x = 1.45$

DETERMINE COLUMN AVAILABLE STRENGTH, W14x53

$$\frac{KL_x}{r_x/r_y} = \frac{1.4(12)}{3.07} = 5.47 \text{ ft} > K_y L = 1.0(12) = 12.0 \text{ ft}$$

$\therefore \phi P_n = 465$ k TABLE 4-1

$L_b = 12$ ft $\therefore \phi M_n = 285$ ft-kips TABLE 3-10

OR:

From Table 6-1, upper and lower columns are the same

$\rho = 2.15 \times 10^{-3}$ $b_x = 3.11 \times 10^{-3}$

17. (continued)

Determine amplification factors

Upper Story

B_1: $C_m = 0.6 - 0.4\left(\frac{86.6}{108}\right) = 0.279$

$$P_{e_1} = \frac{\pi^2 E (541)}{(12(12))^2} = 7470$$

$$B_1 = \frac{0.279}{1 - \frac{(37.9+0.9)}{7470}} = 0.28 \angle 1.0 \quad \therefore B_1 = 1.0$$

B_2: $P_{story} = 2P_{col} = 2(37.9) = 75.8^k$

$$P_{e_{story}} = R_m \frac{HL}{\Delta_H} = 0.85 \frac{(2.9)(12)(12)}{12(12)/300} = 739^k$$

$$B_2 = \frac{1}{1 - \frac{1.0(75.8)}{739}} = 1.11$$

Amplified P & M

$P_r = 37.9 + 1.11(0.9) = 38.9^k$ $M_r = 1.0(108) + 1.11(11.4) = 121^{k\text{-}ft}$

Lower Story

B_1: $C_m = 0.6 - 0.4\left(\frac{21.8}{43.4}\right) = 0.399$

$$P_{e_1} = 7470$$

$$B_1 = \frac{0.399}{1 - \frac{(75.8+3.24)}{7470}} = 0.403 \angle 1.0 \quad \therefore B_1 = 1.0$$

17. (CONTINUED)

B_2 j $P_{story} = 2(75.8) = 152^{K}$

$$Pe_{story\,j} = R_m \frac{\Sigma HL}{\Delta_H} = 0.85 \frac{(2.9+5.8)(12)(14)}{\frac{12(12)}{300}} = 2220^{K}$$

$$B_2 = \frac{1}{1 - \frac{1.0(152)}{2220}} = 1.07$$

Amplified P-M

$P_r = 75.8 + 1.07(3.24) = 79.3\ K$

$M_{r_{top}} = 1.0(43.4) + 1.07(21.5) = 66.4\ ft\text{-}K$ *

$M_{r_{bot}} = 1.0(21.8) + 1.07(30.7) = 54.6\ ft\text{-}K$

CHECK UPPER STORY

$\phi P_r = 2.15 \times 10^{-3}(38.9) = 0.0836 < 0.2 \quad \therefore$ use H1-1b

$\frac{1}{2}(0.0836) + \frac{9}{8}(3.11 \times 10^{-3})(121) = 0.465 < 1.0 \quad \therefore$ OK

CHECK LOWER STORY

$\phi P_r = 2.15 \times 10^{-3}(79.3) = 0.170 < 0.2 \quad \therefore$ use H1-1b

$\frac{1}{2}(0.170) + \frac{9}{8}(3.11 \times 10^{-3})(66.4) = 0.317 < 1.0 \quad \therefore$ OK

THUS, THESE COLUMNS ARE ACCEPTABLE BY LRFD

8-25a

25 a) LRFD assume W12 $P_r = 1100^k$, $M_r = 170^{ik}$, $L = 28'$

$P_{eff} = 1100 + 2.0(170) = 1440^k$

$KL = 28ft$ ∴ Try W12x252 TABLE 4-1 $\phi P_n = 1590^k$

$\rho = 0.629 \times 10^{-3}$ $b_x = 0.594 \times 10^{-3}$

$\rho P_r = 0.629 \times 10^{-3}(1100) = 0.692 > 0.2$ ∴ H1-1a

$0.692 + 0.594 \times 10^{-3}(170) = 0.793 < 1.0$ ∴ OK

8-26a

26.a) LRFD assume W12 $P_r = 350^k$, $M_r = 470^{ik}$

$P_{eff} = 350 + 2.0(470) = 1290^k$

$KL = 14ft$ ∴ Try W12x120 $\phi P_n = 1250^k$

$\rho = 0.779 \times 10^{-3}$ $b_x = 1.31 \times 10^{-3}$

$\rho P = 0.779 \times 10^{-3}(350) = 0.273 > 0.2$ ∴ H1-1a

$0.273 + 1.31 \times 10^{-3}(470) = 0.889 < 1.0$ ∴ OK